CITY OF BOULDER: FOOD WASTE AUDIT

BOULDER FOOD RESCUE

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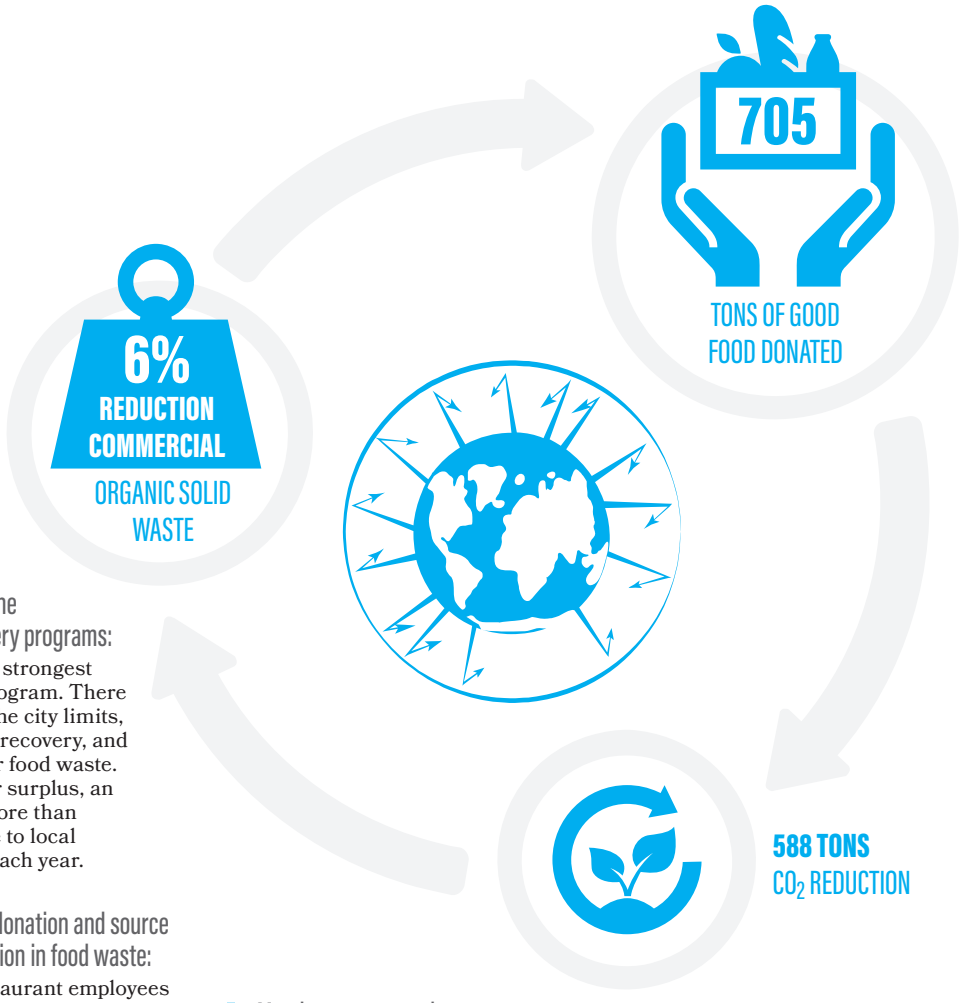
The authoritative version of this document is available at http://boulderfoodrescue.org/2015-waste-audit.pdf.

EXECUTIVE SUMMARY



Restaurants and cafes are the most opportune areas for further development of food recovery programs:

Employees at restaurants expressed the strongest desire to improve their food donation program. There are 265 full service restaurants within the city limits, most of whom do not participate in food recovery, and many of whom who do not compost their food waste. Were these organizations to donate their surplus, an additional 1.2 million pounds of food (more than 1 million meals) could be made available to local organizations who serve those in need each year.

Training programs for food retailers on food donation and source reduction could provide a substantial reduction in food waste:

Forty percent of grocers and 43% of restaurant employees thought their company could increase its training for employees about food waste mitigation. Fifty-nine percent of food retailers in the city of Boulder claim to perform some manner of source reduction for food waste. Specific programs such as waste assessments or trainings for businesses, education about economic benefits, and awards may be effective [39].

- **Education about food recovery must occur at various organizational levels:** Grocers show the largest disparity between manager perspectives and non manager employee perspectives on food recovery systems. Managers have a more-positive opinion of existing food donation efforts at their store than do non-manager employees.
- **Education about federal shield acts is needed in the retail sector:** Nearly one third of employees surveyed suggested that their company may not donate food because of liability concerns.

Food recovery organizations are a necessary component of an effective retail food waste mitigation strategy:

Even with source reduction, food retailers will have large quantities of food available for donation. Boulder has an innovative system of food rescue organizations with multiple coverage at the largest food retailers, but further development is needed to ensure long term sustainability. Existing retail food recovery is responsible for diverting 3% of organic solid waste. Effort to increase participation in donation programs could save an additional 705 tons of good food, up to 6% of the total commercial organic solid waste stream, and *588 tons of CO2 emissions*.

Mandatory composting programs and trash taxes incentivize food donation:

Compost pickup and processing is more costly than landfill waste in western states where tipping fees for landfills is relatively inexpensive. Compulsory composting of food waste (e.g., [22, 32]) and trash taxes create costs (disincentives) for businesses that do not attempt to reduce their waste through source reduction and donation.

Consumer education may reap substantial reductions in residential food waste:

Twenty-five percent of food waste occurs at the point of consumption. Education programs, such as WRAP in the UK that produced a 21% reduction in post-consumer food waste and the EPA food-waste toolkit for municipalities can help consumers understand food waste [23]. These strategies could be well applied in Boulder, where a 21% reduction in residential food waste would divert 628 tons of additional organic waste, equivalent to 525 tons of landfill CO2 emissions.

Processing facilities and commercial kitchens provide means for value-added food recovery and earned-income models:

Prior programs between Community Food Share and the (now closed) Mormon Cannery, existing programs being developed by the Bridge House, and flagship programs in other states, such as the Vermont Food Venture Center [27] show the benefit of processing infrastructure for repurposing food surpluses from both retail and agricultural sectors.

WASTE REDUCTION SCENARIOS

The City of Boulder is well positioned to demonstrate its leadership in zero waste goals through a commitment to reducing food waste. Food recovery organizations in Boulder already divert 3% of organic landfill waste, and 9% of commercial food waste, by redirecting food that might otherwise be wasted to those in need. Table 1 describes five scenarios for additional food waste reduction that leverages the recommendations from this study:

REDUCTION	COMMERCIAL	RESIDENTIAL	ORGANIC WASTE DIVERTED (TONS)	GHG REDUCTION (TONS CO2)
+5%	4%	8%	519.7	433.2
+10%	9%	12%	989.8	826.7
+13%	10%	21%	1329.2	1110.0
+20%	15%	30%	1949.0	1627.0
+30%	30%	30%	3000.0	2504.0

Table 1: Example scenarios for additional reduction in food waste through source reduction and donation. Up to 13% additional reduction can be accounted for by donation and consumer education alone. Further reduction, up to 30% described here, may be accomplished with extensive consumer education and efforts to encourage source reduction and donation at all levels and is of the retail and manufacturing sectors. All programs demonstrate substantial reduction in organic solid waste and greenhouse gas emissions from the same.

KEY RECOMMENDATIONS

- Educate and incentivize food retailers and manufacturers to participate in donation programs
- Implement well-established and tested programs for consumer food waste education
- Develop farm gleaning programs and provide resources for innovative entrepreneurial solutions

ACKNOWLEDGEMENTS

We would like to thank the organizations that agreed to participate in this research. In particular, the food recovery and waste management organizations operating in Boulder contributed substantively to this work through one-on-one meetings and generously sharing their data. In addition, thanks is due to Ryan Elmore and the Denver R Users' Group and Colorado/Wyoming chapter of the American Statistical Association for contributing some preliminary data preparation upon which statistical analysis is built. Xavier Rojas (CU Boulder/BFR) contributed to the initial research design, and Lindsey Loberg and Michael Benko performed data collection in the field. Layout and design of this food waste audit was provided by Rodne Design Studios.

CHAPTER 1
INTRODUCTION

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At all scales and positions in the food system, there is product loss due to a number of factors. Food can go unharvested on farms due to surpluses or perceived imperfections of the product. Food can be discarded during transport, if it arrives late or the buyers' needs change. It will be discarded from store shelves if it goes unsold. At restaurants and caterers there are losses during preparation and service. In our homes food losses occur due to over-purchasing, lack of planning, and confusion over food dating systems. Quantifying the ground truth of these food losses can be challenging. Grocery stores record losses for their internal records, but are not likely to share the information outside of the organization. Individuals throwing away food would have to weigh everything they put in the trash and then share this information, not a common process for anyone. Much of what we know about food losses are based on broad extrapolations from small samples, or models with many parameter assumptions. Those studies that focus on a particular part of the system (e.g., agriculture) may under-treat others, and there is diffculty in comparing surveys that quantify losses in terms of calories and pounds. Taken in the aggregate, these estimates put the range of national losses between 30% and 50% of all food produced [30].

At the retail level, at least 10% of all food inputs are discarded before they can be sold to consumers [21]. These losses are generally due to unexpected surplus, fluctuations in demand, consumer expectations of perfection, and unclear food dating. Largely, this food finds its way into the landfill or compost collection, resulting in a tremendous loss of not only the food, but also the resources that went into producing and transporting that food. Figure 1.1 references two of the largest resources lost when food is wasted. Approximately 25% of the water used in the United States and 300 million barrels of oil a year go to growing food that will ultimately be wasted.

Even more disturbing than the loss of resources is that a substantial portion of discarded food is still edible. For the last 30 years, momentum has been growing to recover this surplus food from the traditional commercial food system and provide it to food-insecure individuals. In Boulder, national organizations such as Feeding America and their affiliates [6], and local organizations such as the Emergency Family Assistance Association (EFAA) and Boulder Food Rescue (BFR) collect and redistribute surplus food from retailers to those in need in the local community.

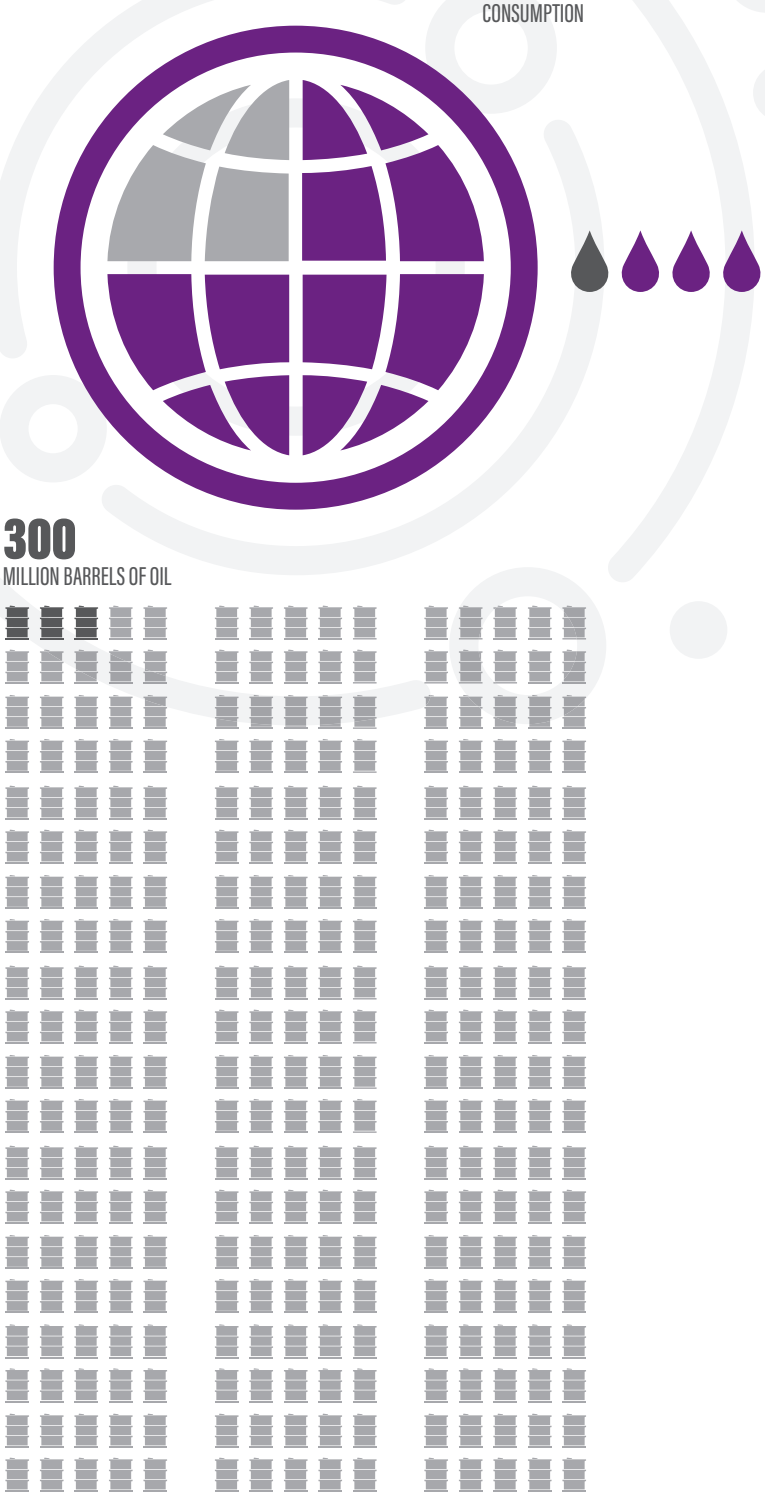


Figure1.1: Food production is resource intensive, and wasted food means wasted resources. Roughly 25% of the freshwater consumed in the US goes to producing food that will ultimately be wasted [26].

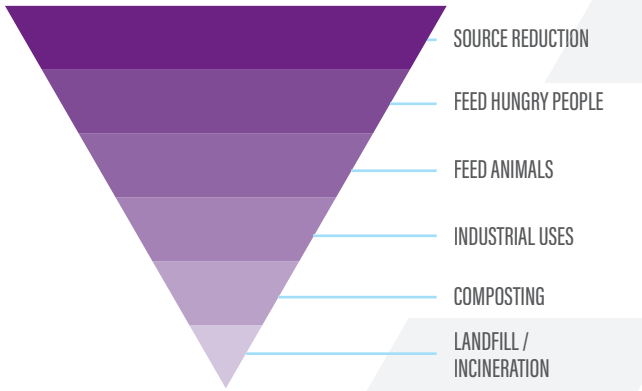


Figure 1.2: The EPA Food Recovery Hierarchy ranks the options for addressing food waste from most preferred at the top of the hierarchy to least preferred at the bottom of the hierarchy. The most preferred option is source reduction, which calls for reducing the amount of surplus food generated. This option requires fewer resources than the options lower in the hierarchy. Donating surplus food is second in the hierarchy, and at the bottom of the hierarchy is dicarding food in a landfill.

Institutions and municipalities around the country are beginning to appreciate the potential benefits of food recovery as a means to feed food-insecure individuals in their communities. This awareness provides great opportunities for simultaneously reducing waste streams, while addressing issues of food access. The Environmental Protection Agency (EPA) and the US Department of Agriculture (USDA) have joined forces in the US Food Waste Challenge to raise awareness of the environmental, health and nutrition issues created by food waste [4, 11]. Together, the USDA and EPA have set national goals for a 50% reduction in wasted food by 2030. Along the same lines, The UN Food and Agriculture Organization (FAO) started SAVE FOOD: the global initiative on food loss and waste reduction [10]. The EPA has created resources and guidelines for food recovery, including the hierarchy shown in figure 1.2 that prioritizes source reduction and donation above composting and industrial uses. In 2014, food recovery organizations, municipalities, and government officials from around the country assembled for the first time in Berkeley, California to discuss national issues surrounding food waste and recovery [3]. Early this year, a report released by UK-based Waste and Resources Action Programme (WRAP) estimated the global cost of food waste at more than $400 billion USD and highlighted a trend towards increasing waste with the growing middle class that may drive the cost to more than $600 billion USD by 2030 [18, 20, 34].

These efforts are complemented by growing interest in modernizing the existing food recovery apparatus with technological resources. Start-up organizations such as CROPMOBSTER [2], Zero Percent [12], and Feeding Forward [7] are introducing new tools to enable additional retail food recovery and organizing “crowd-sourced” volunteer gleaning events. In late 2014, Feeding America announced a collaboration with Google to develop technological resources around food recovery [29].

The growing momentum around reducing food waste is complemented by parallel efforts to increase composting. In 2012 the state of Vermont adopted Act 148, a universal recycling and composting law, which bans organizations and individuals from sending food scraps to the landfill. A number of other municipalities have joined Vermont, including Seattle, San Francisco, and Portland to create similar programs [22, 32]. Mandatory composting programs, along with direct trash taxes, are intended to create incentives for source reduction and surplus food donation by increasing the cost of discarding food. Compulsory composting also benefits food waste reduction by creating a process where companies have financial incentives to separate edible food surplus from scraps. Edible food can be donated, thereby reducing the cost that the company pays for composting.

In 2014, the City of Boulder sent 83,217 tons of trash to the landfill, of which 34,535 tons (41.5%) was organic waste. The commercial sector was responsible for producing 47,026 tons of trash, of which approximately 19,515 tons was organic, including 7,007 tons of food waste (14.9%). Residences (including apartments), generated 22,847 tons of waste, approximately 9,482 tons (41.5%) of organic waste, and 2,993 tons (13.1%) of food waste [36, 35].

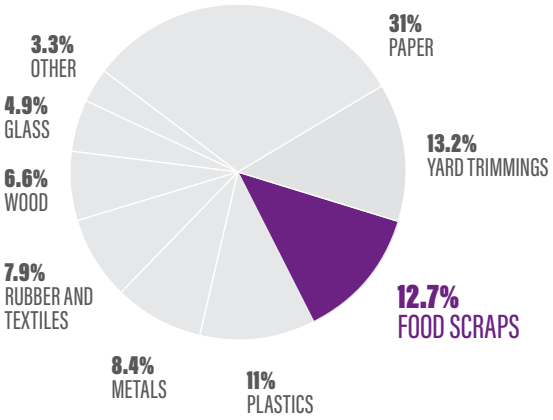
As a diversion strategy, composting was quite successful. Residences diverted 34% (4,974 tons) of their organic waste through composting programs. The commercial sector diverted 12.4% (2,768 tons) of their organic waste through composting programs. Food recovery programs, which recovered a combined 688 tons of wasted food from the commercial sector in 2014, are responsible for diverting 3% of the commercial organic waste stream, equivalent to a reduction of 574.3 tons of landfill-released CO2.

In the next section we discuss the prevailing methods for reducing food waste. Section 1.2 describes the current state of food recovery in Boulder. Lastly, in section 1.3 we will discuss the aims of the research for this study and describe the layout of the remaining chapters.

1.1 MECHANISMS FOR REDUCING FOOD WASTE

There are several best-practice mechanisms for reducing or repurposing food waste described in order of preference by the EPA’s food recovery hierarchy (see figure 1.2). In this section, we’ll describe those that may be of immediate applicability to addressing food waste issues in Boulder, principally source reduction, food recovery and consumer education.

WHAT GETS WASTED IN THE USA?



1.1.1

ENVIRONMENTAL BENEFITS OF SOURCE REDUCTION

Source reduction is the design, manufacture, purchase or use of materials to reduce their quantity or toxicity before they reach the waste stream [39]. Roughly 10% of the entire food supply at the retail level is lost, which is estimated to be about 43 billion pounds of food nationwide, most of which is perishables. The USDA estimates that supermarkets lose $15 billion annually in fruits and vegetables alone [30]. Source reduction is the only waste reduction tactic that is preventative because it reduces material and energy use by counting reduction initially and minimizing energy-intensive processes of waste reuse and recycling [39]. For instance, grocery stores operate under the assumption that consumers prefer fully stocked displays of food. Thus, these grocers commonly overstock produce displays and also keep food fresh until closing time. In this way, produce displays can be seen as a "loss leader" which may result in a net loss for the store in order to attract consumers to other more profitable sections [19]. Given this expected loss, stores can utilize source reduction by adding a prepared food bar, deli, or juice bar to make use of surplus, close-to-code, or damaged product. The EPA recommends source reduction as one of the primary tactics for minimizing waste and suggests that it should be implemented at business and industry levels through many strategies including legislation, education, and economic incentives.

The EPA suggests that local governments should implement source reduction programs at three levels in their communities: (1) the institutional level, including government facilities and other facilities like schools and libraries; (2) the business and industry level and (3) the residential level. In order to influence source reduction at food businesses such as grocery stores and restaurants, local governments could implement specific programs such as waste assessments or trainings for businesses, education about economic benefits of source reduction and recognition for source reduction [39]. Source reduction tactics that stores could be educated about include analyzing needs at the item level, using discount shelves for products near their expiration date, redesigning displays, using produce internally to make prepared foods and not requiring that prepared foods are always available [30]. Food retailers are likely to adopt waste reduction tactics if educational campaigns are available and incentives are produced and made public.

1.1.2

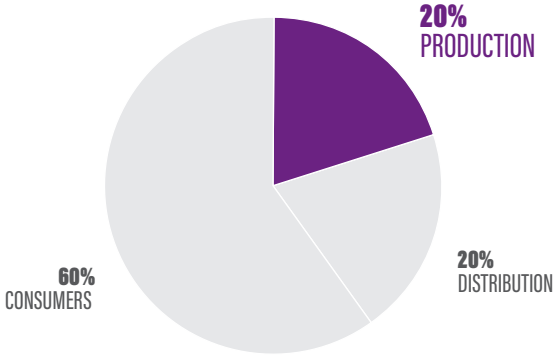
FOOD RECOVERY

Food Recovery is the act of redistributing edible food that would otherwise be wasted to other sources before it hits the waste stream. There are current incentives for businesses to donate surplus food instead of putting it into the trash or compost. There is a national tax credit, 170(e)(3), that allows stores to receive up to half the amount of the net value of the food item if it were to be donated to a 501(c)3 non-profit, creating large tax incentives for stores to donate product as opposed to throwing it away [28]. These incentives are additionally supported by a federal shield act named the Bill Emerson Act (BEA). The BEA protects food donors from associated liability except in cases of gross neglect and is the basis on which hundreds of food recovery organizations and food donors have found a way to operate safely and without liability concerns [31].

Recently, government agencies started programs to encourage businesses to donate more food. The USDA and the EPA created the US Food Waste Challenge in June, 2013, calling on all entities across the food chain to implement new programs in source reduction, food donation and composting. In addition to the US Food Waste Challenge, programs have been created to increase food recovery such as streamlining procedures for meat donation and connecting fresh produce importers with charitable organizations [38].

In the city of Boulder, there are multiple food recovery organizations (as will be discussed in the next section), yet stores need additional incentives and training programs to donate more food that would otherwise be wasted. Currently, only 10% of the surplus edible food in the US is recovered. According to the NRDC, many of the barriers to recovering food include liability concerns, logistical distribution, and funding support for food recovery organizations. Although Boulder has an existing network of food rescue organizations, there is opportunity for new programs to, e.g., glean food from more farms by helping harvest crops that are unsold [30]. Food redistribution organizations can work with stores to host in-house trainings and keep consistent communication to enhance the relationship between stores and their donees.

WHO WASTES IT?



FOOD RECOVERY IN BOULDER

	FOOD RECOVERED (LBS)		FOOD LOSSES (LBS)		DONOR LOCATIONS	
	2013	2014	2013	2014	2013	2014
BFR	248,749	300,293	N/A	N/A	65	106
CFS	929,179	1,032,383	27,875	32,004	48	57
FDC	7,427	2,517	N/A	N/A	10	7
EFAA	29,126	41,000	N/A	4,100	3	3
RWU	N/A	94 pans*	N/A	N/A	N/A	1

Table 1.1: Scale of food recovery and distribution operations in Boulder by Boulder Food Rescue (BFR, Boulder Colorado), Community Food Share (CFS, Louisville, Colorado), Food Donation Connection (FDC, Knoxville, Tennessee), Emergency Family Assistance Association (EFAA, Boulder, Colorado), and Rock and Wrap it Up! (RWU, Cedarhurst, New York). *Rock & Wrap It Up does not weigh recovered food. CFS loss numbers are projected based on overall loss rates as applied to fraction of food recovered from Boulder.

1.1.3 CONSUMER EDUCATION

The average American family throws away 25% of the food and beverages that they buy. This is due to a lack of awareness of wasted food, confusion over date labels, spoilage, and wrongly preparing foods [30]. Some of it is a simple lack of care. For example, according to I Value Food, a program of Sustainable America, 38% of people that take home leftovers from a restaurant end up throwing them away. Individual consumers waste $371 per person per year in the US [17]. Much of this loss may be mitigated by educational campaigns creating taboo around food waste. In the UK, Love Food Hate Waste, a program of WRAP, works to educate consumers about food waste by partnering with governments, organizations, businesses and chefs to raise awareness through campaigning around the need to reduce waste, tips to reduce waste, recipes, planning processes, etc. Between 2007-2012, WRAP reduced avoidable household food waste by 21% in the UK [18]. In the US, the EPA West Coast Climate Forum has already begun a food waste educational campaign called Food: Too Good To Waste. It is a pilot community-based marketing campaign to reduce individual household food waste. It includes five strategies to educate consumers, including: (1) how much money they waste, (2) how to shop smart, (3) food storage, (4) food preparation, and (5) food preservation. It is designed for government agencies to implement on a community level and is accessible for all [23].

Using strategies similar to these, the City of Boulder might reduce their residential food waste from 2,993 tons to 2,364 tons, (21% reduction), amounting to a total reduction in the organic waste stream from residences by 6.6% (628.5 tons), equivalent to a reduction in landfill greenhouse gas production of 524.7 tons of CO2 [16].

1.2 FOOD RECOVERY IN BOULDER

Prior work has shown that even with conservative estimates, there is likely more than enough good food being discarded in Boulder and Broomfield counties to meet the caloric needs of all of the food-insecure individuals in the area [42].

Within the City of Boulder, several organizations already work to recover food before it finds its way to the landfill. Community Food Rescue (Louisville) performs scheduled food recovery during normal business hours at a number of retailers. Boulder Food Rescue (BFR) organizes a large volunteer pool to perform sustainable just-in-time food recovery with bicycles, focusing on the most perishable food items such as fresh fruits and vegetables. In addition to these two, some chain restaurants in Boulder (e.g., Chipotle, Olive Garden) have a relationship with Knoxville, TN based Food Donation Connection [8], which connects them with individual non-profits who can utilize their excesses. In the following subsections we will discuss each organization in turn. Besides their role in direct food recovery, these organizations are well positioned to support municipal implementation of educational programs and incentive structures around source reduction and consumer waste mitigation.

1.2.1 COMMUNITY FOOD SHARE

Figure 1.4: Community Food Share (CFS) is a Feeding America-affiliated Food Bank in Louisville, CO that serves Boulder and Broomfield counties. CFS performed nearly 9 million pounds of food recovery in their entire service area in 2014. Of that total amount, 1 million pounds were recovered from the city of Boulder, 230,000 lbs of which was fresh fruits and vegetables.

Community Food Share (CFS) is a Feeding America affiliated food bank based in Louisville, Colorado that serves the City of Boulder. CFS operates four refrigerated trucks and picks up at participating retailers two to three days per week on a pre-defined schedule. The food that CFS recovers is taken to a central warehouse for sorting and storage, and then distributed to clientele (through an at-warehouse shopping program for families) and to organizations in Boulder and Broomfield counties that serve communities in need. CFS food recovery routes constitute approximately 55,000 miles driven per annum, and resulted in more than 1 million pounds of food rescued in 2014 within the Boulder city limits. Of the food rescued, 22% (230,000 lbs) was perishable fruits and vegetables. A large fraction of recovered food is distributed to recipients. CFS reports a loss rate due to spoilage in their warehouse of less than 3%. Additionally, CFS purchases food and receives surpluses from farms, and in 2014, rescued a total of eight million pounds of food in 2014, some food from as far away as Florida.

1.2.2 BOULDER FOOD RESCUE

Boulder Food Rescue (BFR) is non profit organization that was founded in 2011 to redistribute healthy, perishable, foods such as fruits and vegetables. BFR does this with a direct, just-in-time model. Food is delivered directly from grocery stores to agencies serving homeless and low-income people, by bicycle. BFR picks up from 8 major grocery stores and 14 other small donors such as bakeries, community gardens, the farmers market, and small grocers. This food travels anywhere from one block to two miles. In addition to traditional emergency food assistance organizations, BFR also works directly with low-income housing communities (e.g., Boulder Housing Partners [15]), preschools and daycare centers, to set up grocery programs (resident-driven food pantries) in convenient places to limit barriers of access to healthy food, such as operating hours, physical ability to move across town, residency documentation or stigma associated with food assistance. BFR completes an average of 9 pick ups a day, every day of the week, with 150 active volunteers. Thus far, 88% of deliveries have been completed by bicycle. In just over 3 years, BFR has redistributed a total of 830,000 pounds of healthy food. In 2014 BFR redistributed 300,000 pounds of food total, 214,133 pounds of which (71%) was produce and 14,109 pounds (5%) was fresh or frozen prepared food from cafeterias and restaurants[1].

Figure 1.5: Boulder Food Rescue (BFR) is a food recovery organization in Boulder Colorado that focuses on the recovery of perishable, nutritious food using a sustainable just-in-time model. BFR volunteers rescue food with bicycles and make deliveries directly to recipient organizatios.

1.2.3 FOOD DONATION CONNECTION

Food Donation Connection (FDC) was founded in 1992 to serve as a connector between restaurants and recipient agencies. FDC works primarily with chain restaurants and provides the connection to agencies and reporting guidelines for donors. Food donors are assisted with food safety and handling standards, tax valuation and donation reporting software [8]. In Boulder, FDC works with a handful of chain restaurants including Starbucks and Olive Garden to facilitate donations to local charities. In 2013 these connections were able to rescue 7,000 pounds of food and in 2014, 2,500 pounds.

1.2.4 EMERGENCY FAMILY ASSISTANCE ASSOCIATION

Emergency Family Assistance Association (EFAA) is a non-profit organization that works with community members to support their immediate needs such as food and shelter. In addition to receiving and distributing food from both BFR and CFS, EFAA does a small amount of food redistribution using their own van. In 2014, EFAA recovered 17,000 pounds of produce from Whole Foods Market. They also pick up bread once a week from Safeway, totaling 7,000 pounds. EFAA also does a small amount of food redistribution from Target, totaling 15,000 pounds, but containing mostly processed food and sweets [43].

1.2.5 ROCK AND WRAP IT UP!

Rock and Wrap it Up! (RWU) is a 24-year-old, nation-wide food recovery organization that focuses on connecting recipient sites to events, businesses, and other streams of prepared food waste. In Boulder, RWU works with CU Athletics—a partnership that began in Fall, 2014. Food is picked up directly by Attention Homes [14], a shelter for at-risk youth. Attention Homes hosts 14 residents, serves approximately 20 drop-in clients per day, and performs outreach to youth on the street. Thus far, they have recovered 94 hotel pans of prepared food directly from CU Athletics. Rock and Wrap it Up! provides online software to input data and give receipts [37].

1.3 AIMS OF THIS STUDY

The remainder of this study aims to understand the food waste process in Boulder by measuring both perceptions of food recovery and food waste, and quantifying the current level of food recovery, unrecovered wasted food, as well as potential for further growth in the local recovery system. In the next chapter we discuss the administration and results of a retail food waste survey to assess attitudes, existing protocols, and opportunity for improvement of systems for reducing food waste. In chapter 3 we draw upon detailed data from existing food rescue organizations to extrapolate the potential scale of unrealized food recovery as well as the associated costs which might be mitigated by addressing these losses.

CHAPTER 2
RETAIL FOOD WASTE SURVEY

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To gauge existing adoption of waste mitigation in the food services sector, and the potential for additional growth, we surveyed employees at food-based retail companies within the Boulder city limits about food donation and composting in their organizations. Survey questions also addressed perceptions of food donation and composting, such as whether employees thought the organization should increase its current level of food donation and composting.

2.1
METHOD

To ascertain the locations of Boulder food retailers, we used a selection of 500 restaurants from the Factual location database [5]. This database was augmented with an additional 72 locations from our prior research on retail food waste [42], and the locations of 31 Boulder Food Rescue (BFR) donors [1]. Six locations in the Factual 500 were excluded because they are exclusively bars and do not have substantial food offerings. After merging these databases to avoid duplicates, a stratified random sampling design was used. Our prior work has shown that the food donation process at a given retailer is heavily influenced by the type of food production and distribution they engage in, and the size of the company (using building square footage as a proxy). It stands to reason that grocers would have a very different waste process than cafes, for instance. Because it is desirable to sample each category of retailer, we chose to oversample from the least numerous category (Grocers) and under-sample from the most numerous (Restaurants). In doing so, we were able to get a representative sample from each category. In fact, all 20 grocers within the Boulder City limits were included in our sample. The resulting stratified sampling scheme produced an initial sample of 70 randomly chosen locations.

2.1.1
SURVEY INSTRUMENT

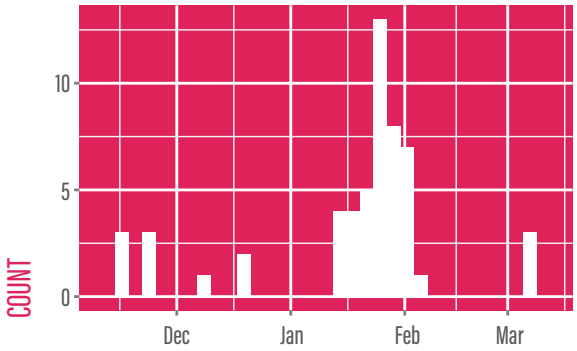
A survey instrument was developed by BFR with collaborators from the Sociology and Computer Science departments at the University of Colorado. The first phase of design involved a facilitated discussion about goals for the survey. This phase produced a set of approximately 50 free-response questions on the topics of food waste, composting, food donation, liability concerns and awareness, and company information. As an example, two of the questions in that initial question bank were, “Is setting aside perishables to donate part of your job description?”, and “Are there any in-store initiatives and systems for reducing the amount of waste the organization produces?”. The final survey was compiled from these questions.

We focused the survey on five principle categories of content questions, motivated by the goals of the audit: (1) basic company information (2) waste stream (3) compost collected (4) food reuse and donation and (5) process and protocol. Each category included multiple questions on the topic. Ultimately, a survey instrument involving 51 questions was developed to measure attitudes of employees, and company protocols (see appendix A). The survey was administered digitally using tablet computers configured with the Quick-Tap survey software [9]. In order to expedite data collection by allowing simultaneous surveying, two tablets were configured.

2.1.2
PILOT STUDY

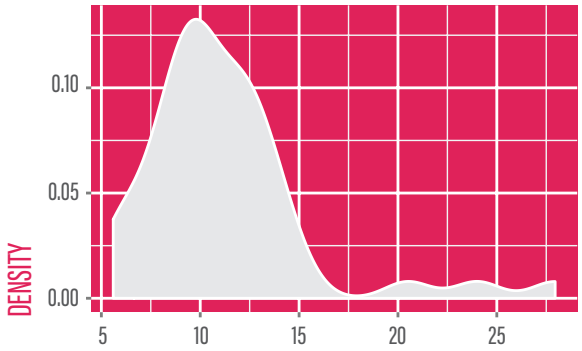
From the 70 locations, 20% of locations (14) were selected randomly for a pilot study to test our survey instrument. These locations were visited during November and December, 2014. After reviewing the results from this pilot survey, we chose to make no changes to the pilot survey instrument or protocol and adopted it as our final method. The remainder of the sample locations were visited during January, 2015. Three final locations that were unavailable in January were visited in March. We chose to pause surveying for two weeks during the holiday season to avoid biased participation[1]. The number of surveys collected on each day in this period are shown in Figure 2.1a.

[1]Food retailers are particularly busy at this time and prior work suggests that the food waste process may be skewed during the holidays.



(A) SURVEY ACTIVITY BY DATE

Figure 2.1: Surveyor Collection Statistics. (a) Survey data was collected in the latter part of 2014 and the beginning of 2015. The pilot study ran during November and December, 2014. After evaluating the pilot data, we re-launched the survey in mid-January and continued surveying until the beginning of March, 2015.



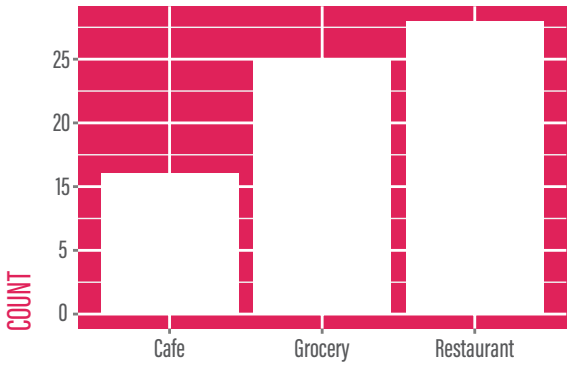
(B) SURVEY RESPONSE TIME IN MINUTES

(b) Time required to complete employee survey. Participants spent an average of 10.2 minutes completing the survey. The minimum completion time was six minutes and a few participants took as long as 28 minutes.

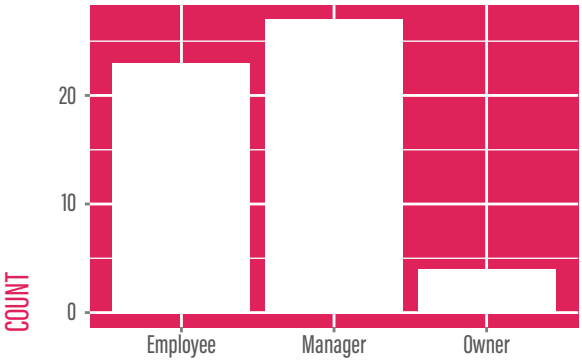
2.1.3 SURVEY PROTOCOL

A standard surveying protocol was designed to encourage participation and create standardization in methods (see appendix B). For each location, surveyors attempted to schedule a time in advance to administer the survey by calling the store manager and explaining the motivation for the survey and the desired level of participation from the store. Surveyors also explained that the survey was part of a food-waste audit commissioned by the City of Boulder as part of its zero-waste initiative. Twenty-four locations (34%) were excluded because they were found to be closed or had moved outside of the city limits. Ultimately, all of the remaining locations were visited. Those locations that were determined to be open were given an opportunity to schedule a convenient time for surveying. At each location, we attempted to survey at least two employees: a manager and an employee who works with food. Following standard best practices for survey administration, each participant was provided a consent form, and consent was obtained prior to filling out the survey (see appendix C).

Fourteen (20%) of locations visited refused to participate in the survey after multiple requests. Largely, we found participation was most impacted at large S-Corporations (i.e, Safeway, King Soopers, Starbucks, Target) who either had policies prohibiting their employees' participation in surveys, or refused in particular to allow their employees to participate in a survey about food waste. At locations that did choose to participate, some locations were more participatory than others. In some cases, only managers or marketing personnel were allowed to complete the surveys.



(A) COMPANY TYPE

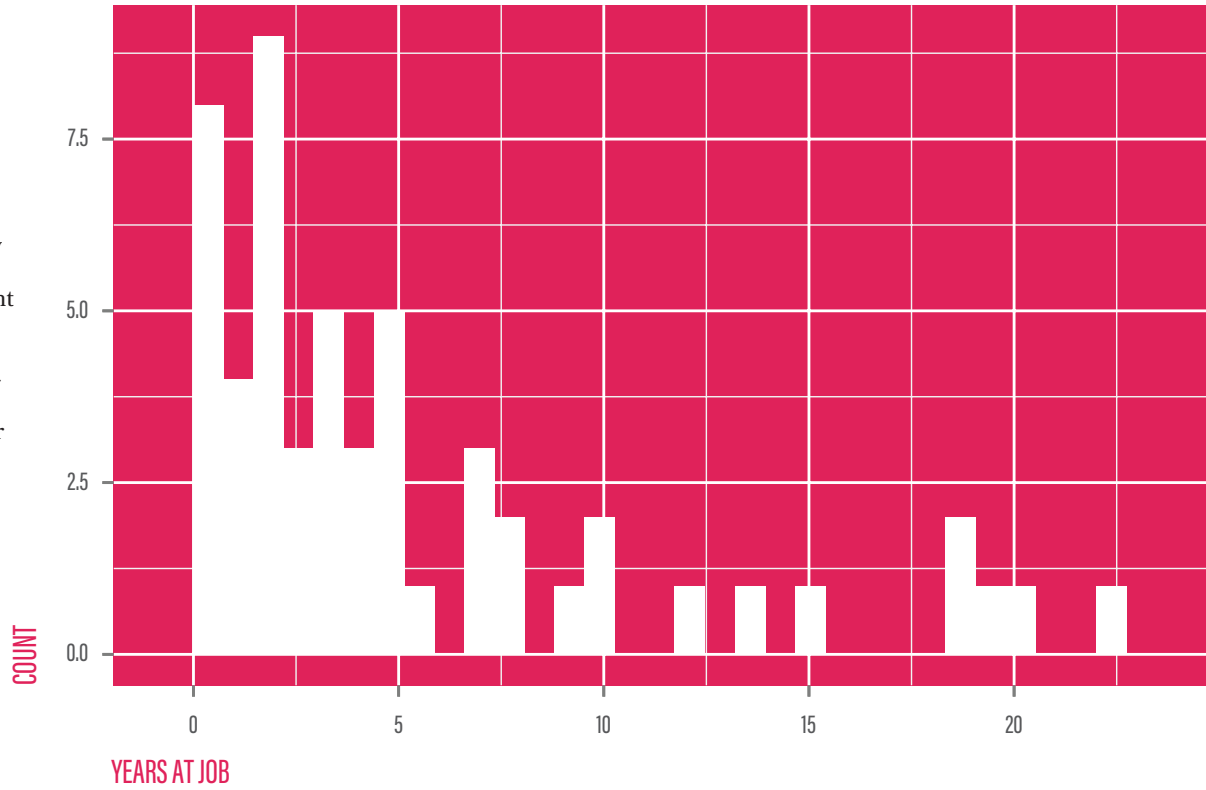


(B) EMPLOYEE TYPE

Figure 2.2: Employee type and company type of survey respondents. Restaurants had the hightest number of respondents, at almost 25, followed by grocers at 20. Very few owners participated in the survey, while the number of managers and non-manager employees was approximately equal.

JOB TENURE

Figure 2.3: Number of years at their current job for survey respondents. The majority of respondents had been at their current job for between zero and five years, while a few respondents had been at their current job for around 20 years.



2.2 RESULTS

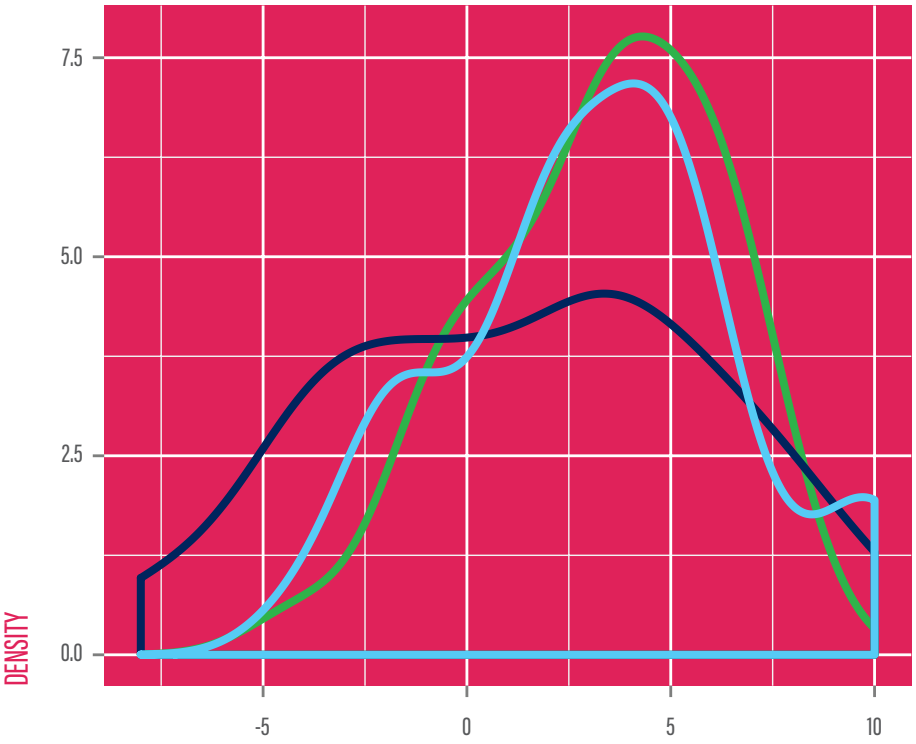
In sum, 54 individuals at 49 locations consented to the survey and spent an average of 10.2 minutes completing it (see figure 2.1b). Restaurants (43%) and grocers (37%) are best represented in the data. Managers were more likely to fill out the survey than non-manager employees. At 46% of locations surveyed, managers or owners completed the survey instead of their employees[2]. At 40% of locations, we were successful in surveying both management and non-management employees. At 11% of locations only non-management employees were available to complete the questionnaire. Eighty-seven percent of responders were full-time employees and 13% were part-time.

The participants span a wide range of experience, from 5 days on the job to more than 20 years, with the bulk of participants having been on the job for fewer than 5 years. This distribution is shown in figure 2.3.

2.2.1 ATTITUDE TESTS

The survey contains three Likert composite questions to measure participant attitudes. Each Likert question contains 5-6 statements designed to present the question in different ways. Participants are asked to indicate the extent to which they agree or disagree with each statement, and their view on the composite question is obtained by normalizing their responses to these individual statements. Likert methods have been shown to be effective at measuring subjective attitudes in a comparable way [40]. For our survey, as a pre-processing validation step, we normalized the answers towards positivity (i.e., responses to negative statements were inverted) and checked responses to these statements for internal consistency using Cronbach's alpha, a standard method for measuring agreement between constituent questions in a Likert-type survey instrument. Based on these results, we chose to exclude statement 5 from the compost question (improving the alpha from 0.73 to 0.75), statement 2 from the waste question (improving the alpha from 0.68 to 0.73), and statement 6 from the donation question (improving the alpha from 0.80 to 0.88).

[2]Our surveyors attempted to give the survey to at least one manager and two non-manager employees at each location, however some locations would not allow their non-manager employees to complete the survey.



LIKERT RESPONSE DISTRIBUTION

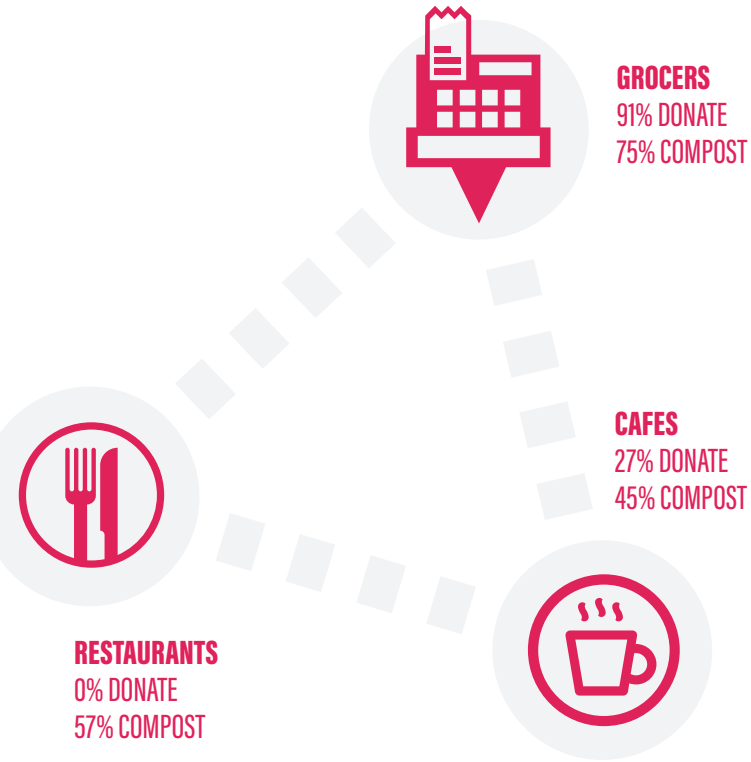
Figure 2.4: Likert response distribution for food donation, composting, and waste. The peak in the compost and waste responses shows that most participants had consistent views on these topics. For donation, however, there are two peaks in the data, indicating that views on food donation were not consistent. Closer examination of the data shows that managers and non-managers expressed different views on whether their organization was doing everything it could regarding food donation.

FOOD WASTE COMPOSTING DONATIONS

A first look at the responses in Figure 2.4 shows that the response distribution for the waste stream and composting questions are fairly harmonious, while the responses for donation appear to be bimodal, with more negative scores overall. Looking just at those responses with a negative sum for the donation question in figure 2.5, we see a bias in the responses towards non-manager employees at restaurants.

The median sum attitude about donation among non-manager employees is 0 and for managers is 4. A Wilcoxan rank sum, which compares the central tendency of two populations, confirms a statistically significant difference between these medians with p-value of 0.002. Similarly, the median among grocery employees is 4.5, compared to -1 among restaurant employees. This difference is also significant with p-value less than 0.001. The largest disparity between manager attitudes and employee attitudes occurred at grocers, where the average employee had a summed attitude of 0, while the average manager expressed a summed attitude of 6. At restaurants the difference is similar, but less significant: -1 for employees and 1 for managers. The difference in attitudes for non managers and managers with respect to composting and waste does not appear to be significant. These results suggest that overall non-manager employees had a less favorable impression of their participation in food donation programs and their waste process overall. It stands to reason that these employees, who handle the food directly may have different perceptions about the efficacy of their organization's attempts to reduce waste.

Figure 2.5: Employee type and company type in responses with negative views of food donation practices. The number of employees who expressed negative views of their organization's food donation practices was highest at restaurants and among non-manager employees.



2.2.2 WASTE REDUCTION

Next, we look at programs for reducing food waste. Sixty-one percent of those surveyed report that their organization composts food waste. Seventy-five percent of grocers claim they compost, compared with 57% of restaurants and 45% of cafes. Forty-eight percent of those surveyed indicated that their company had an employee (or more than one employee) in charge of sustainability issues. This fraction is roughly consistent across type of store, with 45% of cafes, 55% of grocers, and 43% of restaurants.

Participation in food donation varied substantially by business type. Ninety-five percent of grocery employees said their organization donated surplus food compared with 0% of restaurants, and 27% of cafes. Although several participants indicated that there were organizational incentives for donating surplus food such as tax deductions, credits for composting, and reduced tipping fees (trash hauling), no responders indicated that there were incentives for employees to participate in food donation. Thirty-five percent of participants indicated that there was training provided on food donation. When asked to elaborate on how training around food donation might be improved, respondents indicated that they had concerns about food safety: better information about guidelines for food donations with respect to manufacturer "use by" and "sell by" dates, food safety training (for donations), clear examples of food fit for donation versus composting, and generally better institution of training and documentation.

Fifty-nine percent of those surveyed indicated that their organization used systems of source reduction (55% of grocers and 57% of restaurants): reusing surplus food internally before it was wasted. Thirty-three percent of those surveyed said that staff take home or consume surplus food. Employee consumption of surplus is most common at cafes (73%) and restaurants (39%), but fairly uncommon at grocers (5%). When asked to elaborate on their methods for source reduction, several restaurants mentioned reusing excess for the next day's meals. Grocers were more likely to mention use of excess produce in the deli or at a juice bar. Twenty-six percent of those surveyed provided surplus or past-code food for sale at a discount. Overall, 39% of employees thought their organization could do more to reduce food waste. Consistent with the corresponding Likert test, this sentiment is most present at restaurants (43%) and grocers (40%), followed by cafes (27%). Although well-established federal shield laws protect all organizations from liability associated with food donation [31], 30% of those surveyed said that their organization might choose not to donate food because of liability concerns and 7% said their organization might choose to avoid donations because of harm to brand image, believing that imperfections in the donated food would be perceived as representative of the quality of the food available at the store.

2.3 ADDITIONAL SURVEYS AT RESTAURANTS

A second phase of surveying was used to sample additional restaurants. In May of 2015, 20 additional restaurants were visited and 34 individuals were surveyed from a random sample of 50 additional locations. During this phase additional questions were added to address questions from the prior analysis:

1. Are those restaurants with "hot bars" likely to produce a larger quantity of food waste?
2. Is front-end (i.e., customer) or back-end (i.e., kitchen) food waste most dominant, and in which types of restaurants?

Results from this additional sample largely agree with the results from the stratified random sample presented above. Half (50%) of restaurants surveyed participate in composting programs. 67% of those surveyed indicated that their organization used systems of source reduction: reusing surplus food internally before it was wasted. 50% of those surveyed said that staff take home or consume surplus food. When asked to elaborate on their methods for source reduction, several restaurants mentioned reusing excess for the next day's meals. 21% of those surveyed provided surplus or past-code food for sale at a discount.

With respect to the new questions, those restaurants with hot-bars did not claim to produce more wasted food than those without hot bars. We also observe that restaurants expect that the majority of waste is due to their customers (not their kitchen). 9% of those surveyed said they have daily hot bars and 6% semi-weekly. 38% of participants suggested that waste was consumer-driven (75-100% consumer, 25% or less in the kitchen, none having hot bars). Managers and employees seem to agree on this. 26% of respondents believed waste is split approximately 50/50 between the kitchen and customer waste. Only 6% indicated that waste was kitchen-dominated (as reported by managers,

at organizations without hot bars). Ultimately this data does not seem to clearly support the hypothesis that restaurants with hot bars generate more waste. Although this result cannot be confirmed without a detailed composition study at restaurants, it suggests that consumer education may be beneficial for reducing waste at restaurants.

Nearly all, 91%, of those surveyed claimed they had less than 50 pounds of food that could be donated per day and 9% indicated they have between 50 and 100 pounds to donate per day. This result comports with our analysis in the next chapter, which discusses quantities donated from participating restaurants. Recoverable wasted food from restaurants is smaller in quantity than grocers and manufacturers, however there are far more restaurants, resulting in substantial combined waste. Respondents agreed that few barriers exist to donation, yet only a small fraction of restaurants participate in donation programs. Those who did have concerns about donation cited liability (26%) or brand/image (9%). Overall, 53% of employees thought their organization could do more to reduce food waste. Based on these results, reducing restaurant food waste will likely require a combination of creative recovery and donation strategies, paired with consumer education in restaurant-specific source reduction.

2.4 LIMITATIONS

This survey was administered to grocers, restaurants, and cafes. However, the survey was not administered to farms or manufacturers even though they represent a large source of potentially recoverable food. In future work we hope to develop an appropriate survey methodology for these organizations.

We suspect that non-participation, particularly by large retail grocers, skews our results to the positive (i.e., composting and food donation of perishables is more common than it actually is, and there is less waste than there actually is). Prior work modeling the food waste process has shown a clear correlation between the size of organization and both the average and extreme case food losses [42]. Yet, these same organizations are most cautious about their communication with respect to those losses and in many cases refused to allow their employees to be surveyed. In the next chapter, we will attempt to extrapolate the recoverable food waste process of organizations using a statistical model.

At the outset of this study, we hoped to investigate correlations between survey responses and ground-truth data from trash and compost haulers. Unfortunately, we were unable to obtain information from the area trash hauler, Western Disposal, in time to be included in this study. Boulder's primary compost hauler, EcoCycle, provided data for those locations who consented to share it. However, the sample size of locations for which detailed data was available is too small to make claims with meaningful statistical power.

KEY FINDINGS FOR RESTAURANTS

53% OF EMPLOYEES BELIEVE MORE COULD BE DONE

91% CLAIMED LESS THAN 50 POUNDS OF DAILY POSSIBLE FOOD DONATION

50% PARTICIPATE IN COMPOSTING AND/OR ALLOW STAFF TO CONSUME SURPLUS FOOD

2.5 SUMMARY

Overall these results suggest that there is room for improvement in waste reduction strategies at Boulder food retailers. Restaurants appear as the most opportune area for improvements as only slightly more than half of those surveyed participate in composting programs, 57% use some kind of source reduction, and 0% of those surveyed suggested that they participate in regular donation of surplus food. Based on these results, we chose to conduct an additional expanded survey focused on restaurants. At all locations there appears to be opportunity for education. Areas where education may prove particularly effective are around confusion about liability of food donation, training on source reduction, and creating incentives for systems that address organizational waste systematically. To maximize efficacy, education should occur across management boundaries to emphasize inter-hierarchical communication and bridge apparent divides in food waste knowledge between managers and their employees.

CHAPTER 3
ESTIMATING RETAIL FOOD LOSSES

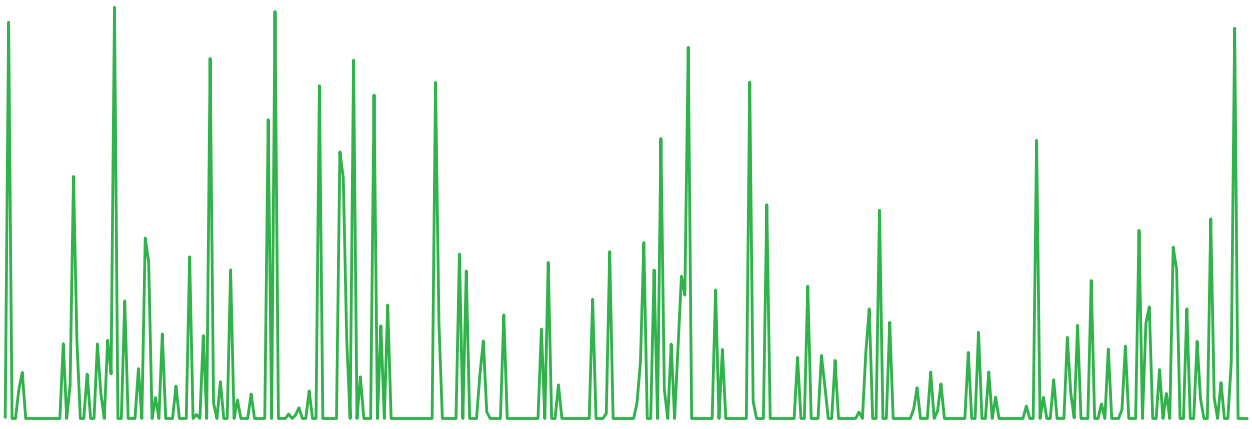
CHAPTER 3
ESTIMATING RETAIL FOOD LOSSES

One method for estimating the scale of food waste (and potential donations) is to extrapolate from data collected by existing food rescue organizations. If we know the amount and types of food a store donates, then we can predict the food available for donation for another, similar store that doesn't currently donate. Food rescue organizations keep detailed records of their recovery for purposes of quantifying impact, tracking assets, ensuring accountability, and, perhaps most importantly in this area, providing tax-deductible receipts to donors. Prior work using data from CFS in isolation has shown that food recovery at individual donors follows a heavy-tailed process, and can be well modeled with extreme value theory and a peaks-over-threshold (POT) model [41].

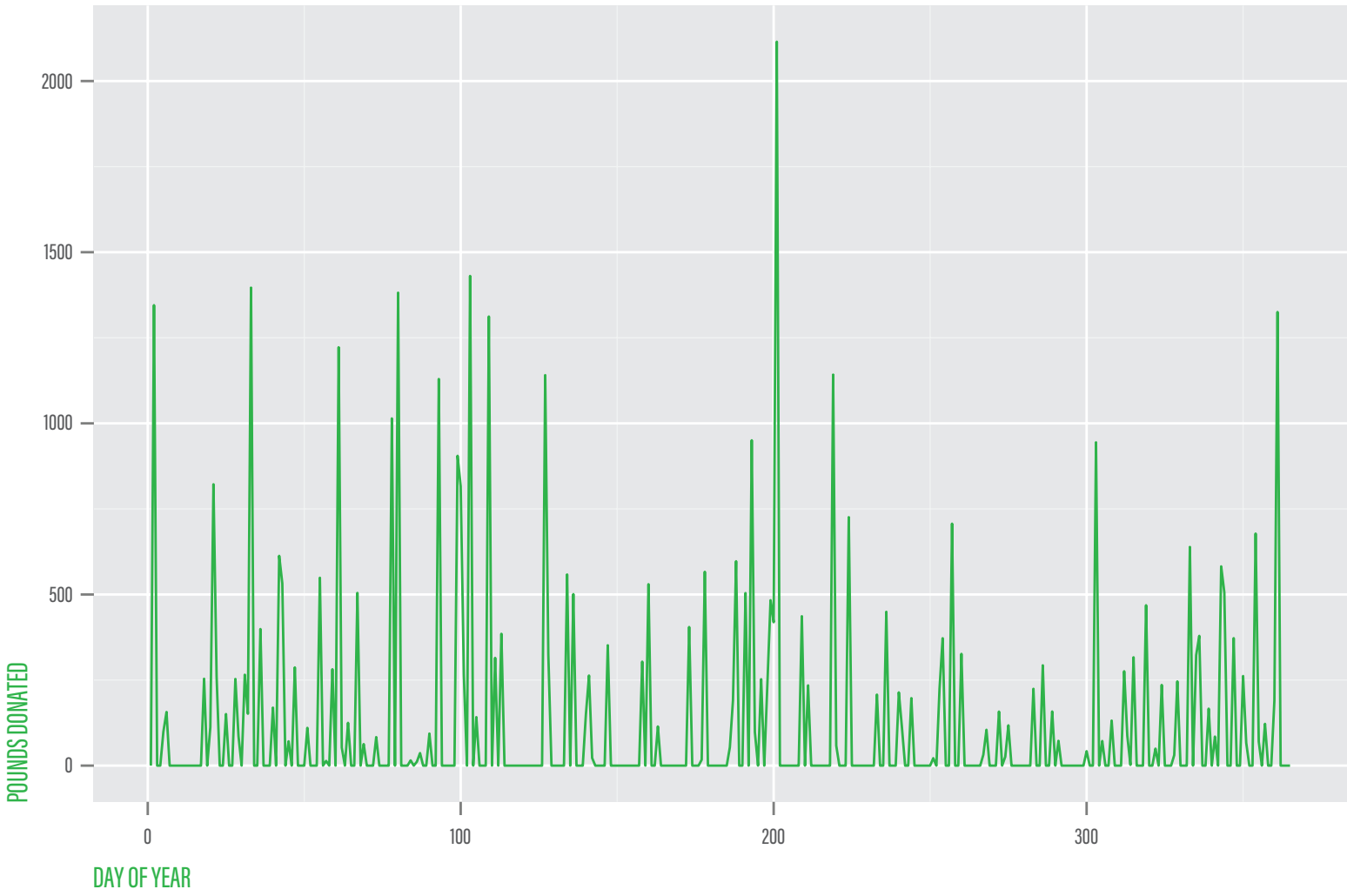
A peaks-over-threshold model is a common model from extreme value theory, which accepts that a certain number of observations will be below a given threshold, but the peaks above it will behave as if heavy-tailed [24]. Since these same models are also heavily utilized in weather forecasting, there is a natual analogy to be made: the food donation (surplus) process is much like rain in Colorado—on many days there is no rain, or very little rain. On some days it rains, and on a few days it rains heavily. On very few days it rains very heavily or may flood. Food donation exhibits this same shape of variability. On some days, there is no surplus food, a fact that occurs due to a variety of factors. On most days, there is a moderate amount of food available for donation (e.g., several hundred pounds at a typical grocer). On rare days, there is an extremely large amount of food available (e.g., ten thousand pounds of frozen turkeys in late November). However, even with this variability in individual donations, aggregated food donation behaves like a stable watershed that is exceedingly reliable over the long term.

As an example, consider figure 3.1a, which shows a representative donation pattern for a CFS grocery store donor. On approximately 70% of days, there are no donations at all. On many days there are large donations, and on some days there are very large donations. However, taken in the aggregate, we can estimate the range of total annual donations to be between 20,000 and 60,000 lbs, with an average of 40,000 pounds for this donor. A histogram showing the frequency of a donation of a given amount for the same representative donor is given in Figure 3.1b. As displayed in the graph, there are approximately 250 days when the pounds donated is zero. There are also approximately 10 days when over 1,000 pounds was donated, and one day when over 2,000 lbs were donated. Figure 3.2 shows this expected annual distribution. The graph peaks at approximately 40,000 pounds annually.

In the CFS data, there are additional parameters potentially affecting the distribution. CFS has a pick-up schedule for its donors, approximately 2-3 days per week between Monday and Friday. Food collects at the store until CFS picks it up. CFS focuses on food that can be stored in a warehouse and then redistributed to smooth out the peaks and valleys in food donation. This warehouse model may limit the ability to recover highly perishable food. As a result, non-perishable and storage-ready fresh foods are most preferred. CFS is able to recover food at large retail grocers and manufacturers. They do not recover food at cafeterias, restaurants, or caterers. In the city of Boulder, Boulder Food Rescue fills this remaining niche with a just-in-time model, seven days a week, that can recover both highly perishable and surplus prepared foods. In the next section we will look at data from BFR to build upon our prior characterization of the food recovery process at CFS and augment that model with a new model for highly perishable food recovery.



(A) DAILY DONATIONS FOR AN EXAMPLE GROCERY-TYPE CFS DONOR



(B) SIMULATED DONATION DISTRIBUTION (HISTOGRAM) OF TYPICAL CFS GROCER

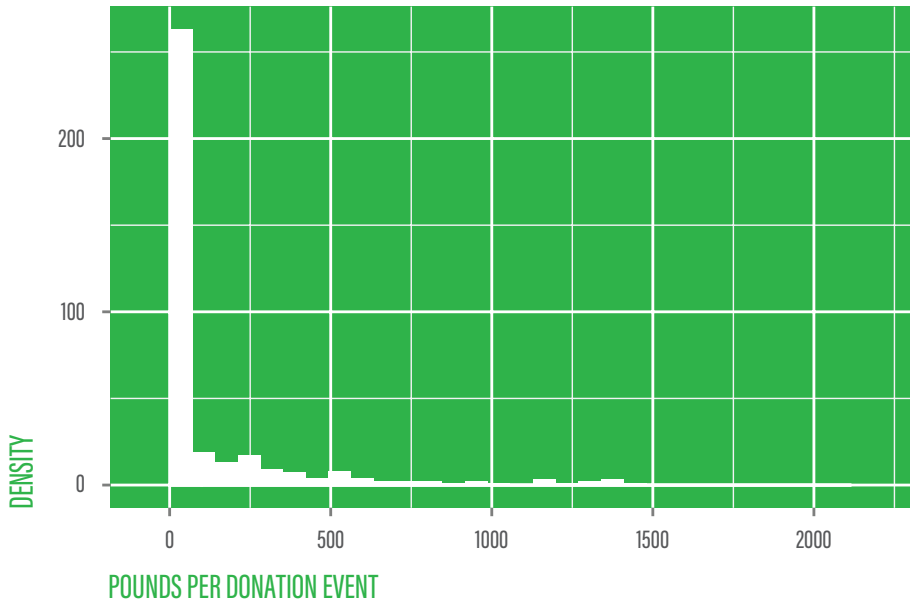
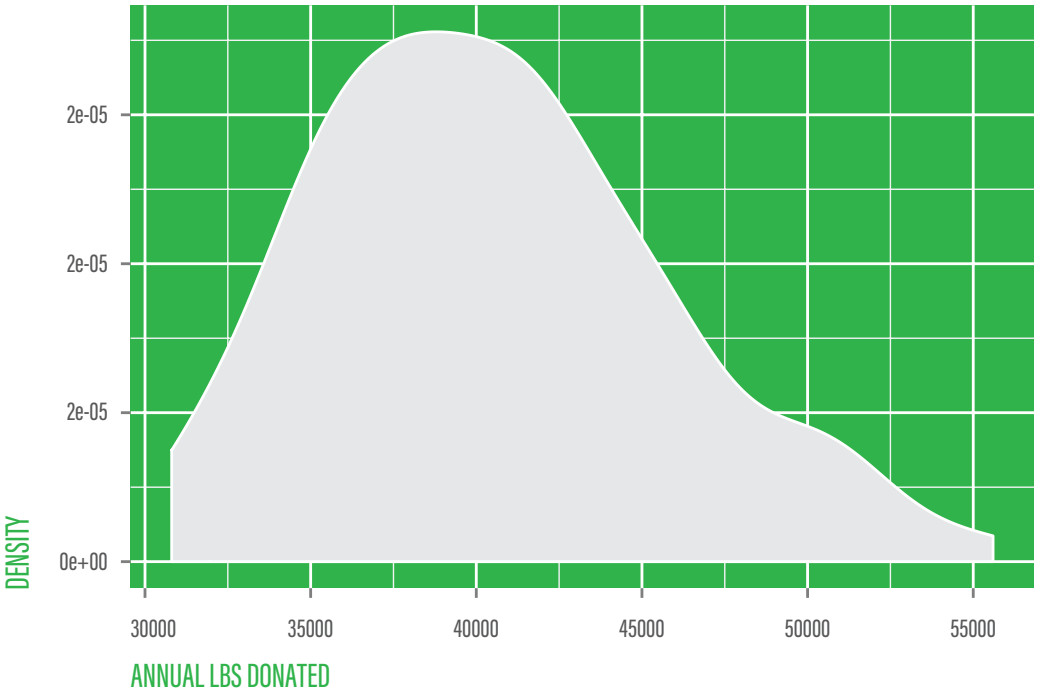


Figure 3.1: Representative grocer donation pattern and weights based on modeled data from CFS. The donation pattern shows a daily variance in donation levels, and reflects a heavy-tailed process of food donation. On most days, the amount of food donated by this representative grocer is small or non-existent. However, on a few days a year, donations spike to over 1,000 lbs of food.



PREDICTED DISTRIBUTION OF ANNUAL CFS GROCER DONATION

Figure 3.2: Probability density function describing the annual aggregated amount donated from a typical grocer and expected range (uncertainty). The predicted donation amount is 40,000 lbs of food annually.

3.1 STATISTICAL MODEL

We analyzed two and a half years of data from Boulder Food Rescue from July, 2012 to December, 2014. This data includes 14,576 food pickups, totaling 678,444 lbs of food recovered from 35 unique donors. Among those donors are 29% restaurants, 49% grocers, 6% food manufacturers, 6% cafeterias, and 15% special events, such as holiday parties. Grocers dominated the donation statistics by both frequency and weight.

At a baseline, we see that the same heavy-tailed models apply to the BFR data as they do to CFS data, although with smaller average donation. This is an important result in and of itself as it suggests that the food donation process may have similar dynamics even when viewed through the lens of differing recovery models and scales of operation[1]. BFR has smaller transportation capacity[2] and focuses on the subset of food donations that are the most perishable. Figure 3.3a shows the empirical distribution for an example grocer. This grocer is a typical, established BFR donor that volunteers pick up from seven days a week. On most days, there were 0-20 pounds of food available, but on a few days, there were 400-500 pounds of food available.

Restaurants have a different shape and scale parameters[3] that show less food per donation and smaller variance in donation sizes. However, they appear to be well modeled with a POT model as well. Figure 3.3b shows the distribution for an example restaurant. On most days, there were 0-10 pounds available. But, on occasional days, BFR picked up 60 pounds of food.

Using a method similar to that of [41], we also looked at this data to discern any potential correlation between the scale of the statistical model and the size of donor. There are several metrics to consider for measuring the size of a donor, such as square footage, annual sales, number of employees. In other words, whether it is possible to predict the average size of a food donation event by using the square footage of the donor's facility. As with the food bank recovery data, we see a correlation between store square footage and donation size with a shallow but significant slope. Figure 3.4 shows the relationship. Modeling least squares regression suggests that square footage is a significant predictor (p-value less than 0.01) with a R-squared of 0.40. Although the residuals seem normal, two stores with abnormally large donations for their square footage (nearly twice what another similar sized store would donate) and one store with abnormally small donations (approximately half of what another similarly sized store would donate) for their square footage are outliers worth considering. Discussions with BFR operations management staff indicate that these outliers may be caused by cultural effects including better or poorer adoption of food donation programs and ordering and purchasing habits (one donor is a new store and may still be fine-tuning its expectations of purchasing patterns). Besides being an interesting result here, we observe that identification of outliers like these may provide a method for automatic detection of over-or under-donating stores where there may be process or protocol problems that can be systematically remedied.

[1]This also supports the notion that food recovery data can be used as a proxy for, more diffcult to obtain, detailed food waste data.
[2]Boulder Food Rescue bicycle trailers have a maximum capacity of between 200 and 600 pounds due to a variety of trailer designs and configurations.
[3]Shape is a measure of variability and scale is a measure of central tendency, or mean.

3.2 RESULTS

In order to make categorically appropriate extrapolations, we fit the combined donations for all grocers and restaurants separately using a POT model. Using these models, we can compute a simulated behavior for an average BFR donor using a Monte Carlo method. Figures 3.5a-3.5d show simulated grocer and restaurant donation distributions along with average aggregate annual donations and variance. These models suggest the average annual donations for BFR donors vary between 17,000 and 26,000 pounds (mean 21,000) for each grocer and 3,700 to 5,800 pounds for each restaurant (mean of 4,600)[4].

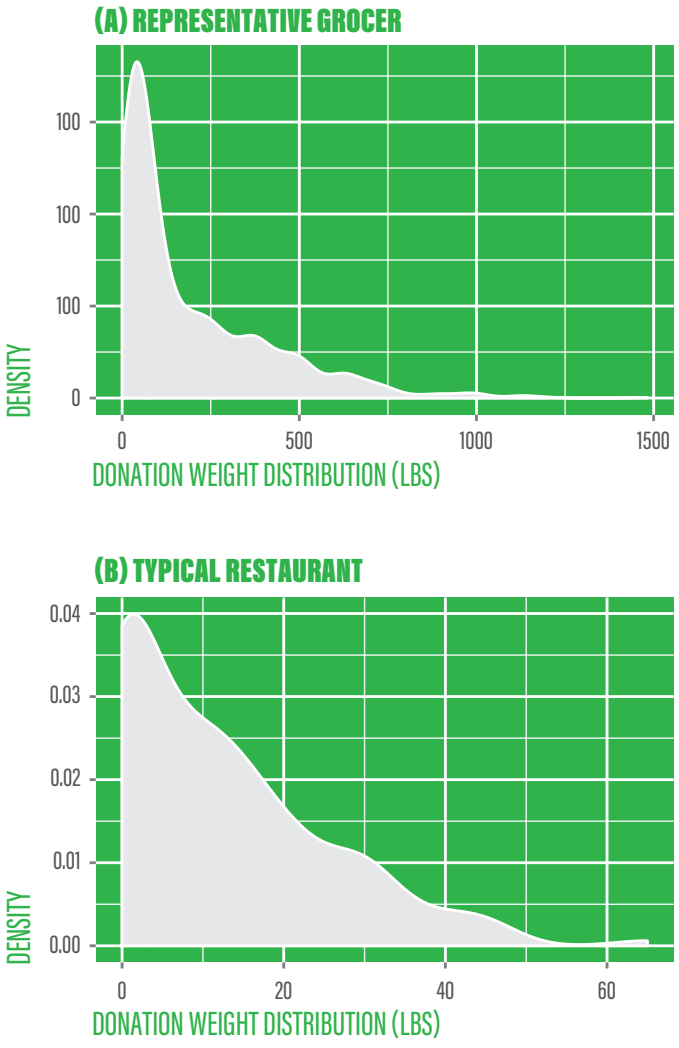


Table 3.1 gives aggregate waste hauling numbers for organizations by category for 2014. Based on these numbers, these amounts correspond to between 4.6 and 7.1% of the compost generated for grocers, and 11.6 to 18.2% of that for restaurants. For grocers, this amount complements the food rescued simultaneously by CFS[5], which based on 2010 numbers, would be approximately 20 tons, or an additional 11% of the compost stream (in combination resulting in a 6.5% reduction in the total waste stream). Because compost hauling in Boulder County is more costly than trash hauling [25], this amounts to a savings in hauling fees of $1995.00 to $2310.0 per year, per grocer and $129.50 to $203.00 per year per restaurant. Expanding upon these predictions, we can make predictions of potential annual donations at six large grocers within the City of Boulder who do not currently donate to BFR[6]. Reasons for failure to participate vary, but generally large corporate grocers are unwilling to work with local food recovery organizations on the basis of broad corporate policies that are slow to change. Figure 3.6 shows the predicted annual poundage currently uncollected at each of these stores.

Because these nonparticipating grocers are quite large relative to some other grocers, the scale of their unrecovered food is quite large. According to this model, there may be well more than 210,000 pounds of food annually being discarded at these six locations that are not currently participating in food recovery. This is potentially equivalent to 187,499 meals[7] . As compost is more expensive to haul than landfill waste, this potentially recoverable food also represents a cost of $7,350 (hauling fees) and as well as a substantial unrecovered tax deduction under IRS code 170(e)3 [44].

Although logistically more difficult to recover, the potential for recovery among restaurants is even more impressive. For instance, if all 265 restaurants with full service menus within the city of Boulder were to begin donating surplus food, the combined annual donations within the City of Boulder could potentially be as much as 1.2 million additional pounds of food [33], or 1.07 million meals. Were all grocers and restaurants to participate in food recovery, as much as 705 tons of additional food might be recovered, which constitutes an increase in total diversion of commercial organic waste from the current 3% to 6.1%, and an additional reduction in landfill greenhouse gas emissions of 588.6 tons of CO2.

Figure 3.3: Representative grocer and restaurant donation weight distributions in BFR data. On most days, there were 0–20 lbs of food available at the grocer, but on a few days, there was 400–500 lbs of food available. The restaurant donations exhibit the same pattern. On most days, there were 0–10 lbs available. But, on occasional days, BFR picked up over 60 lbs of food.

[4]The most consistent BFR donor restaurants are those with buffets (“hot bars”), so our analysis here has a sampling bias towards restaurants with buffets.
[5]See section 3.4 for a discussion of possible issues with this assumption.
[6]Several of these stores do in fact donate to CFS and EFAA, but for this analysis we are attempting to quantify the additionalmissed opportunity for more perishable recovery using the BFR model.
[7]Pounds per meal calculated using 2009 data from the U.S. Census Bureau [13], which suggest the average American consumes 1,226 pounds of food annually, amounting to 1.12 pounds per meal.

A FITTED RELATIONSHIP

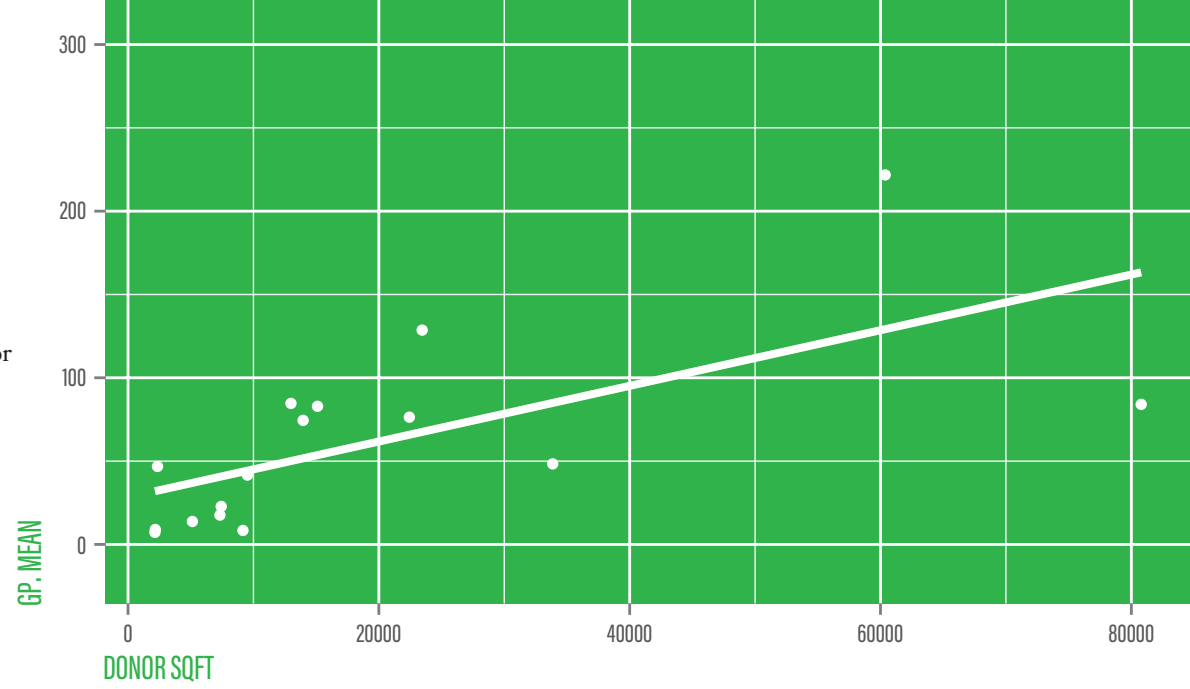


Figure 3.4: Fitted relationship between size of donor (square footage) and average donation in lbs (scale of Pareto model). The graph shows that the average donation size increases with the square footage of the store.

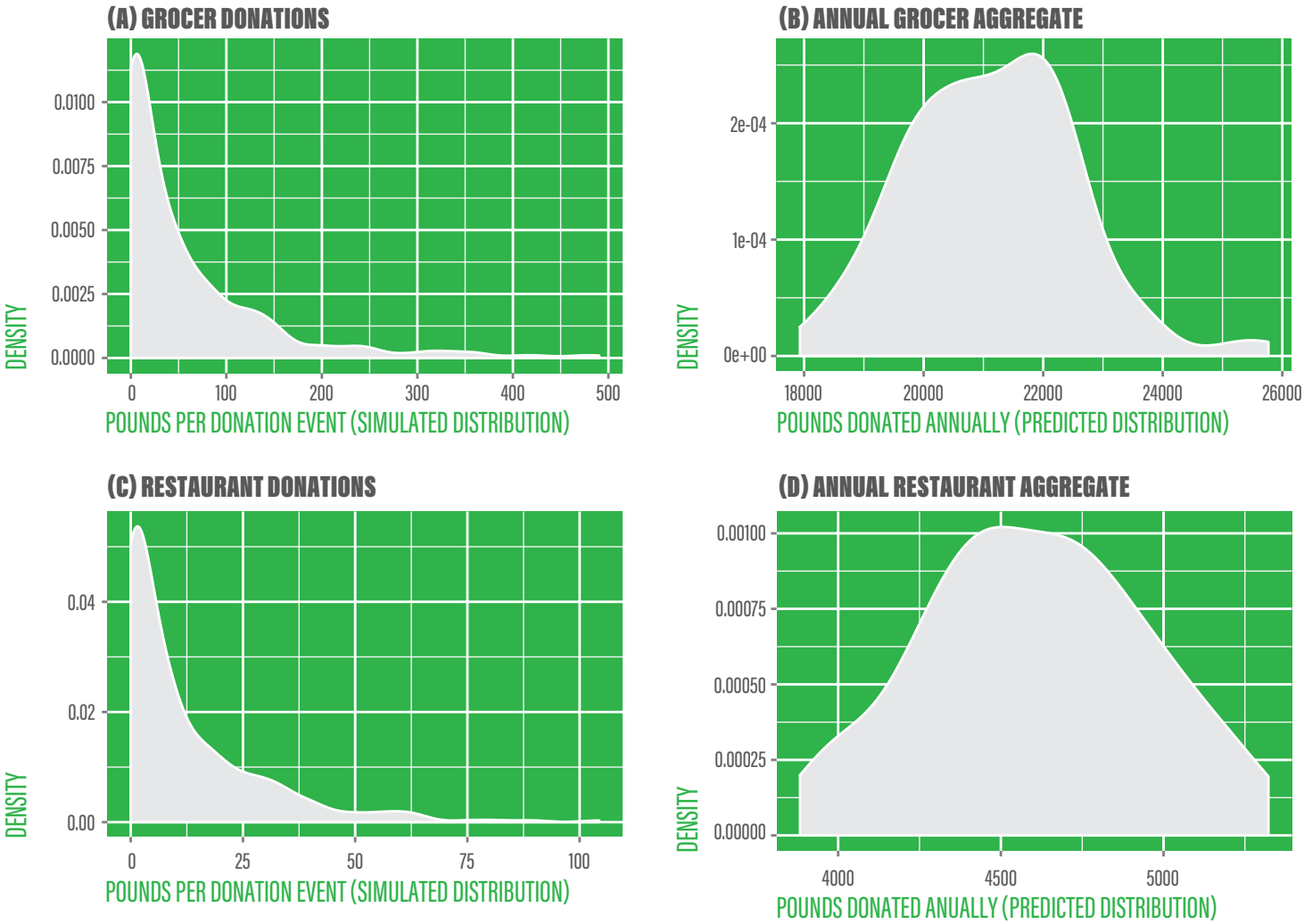
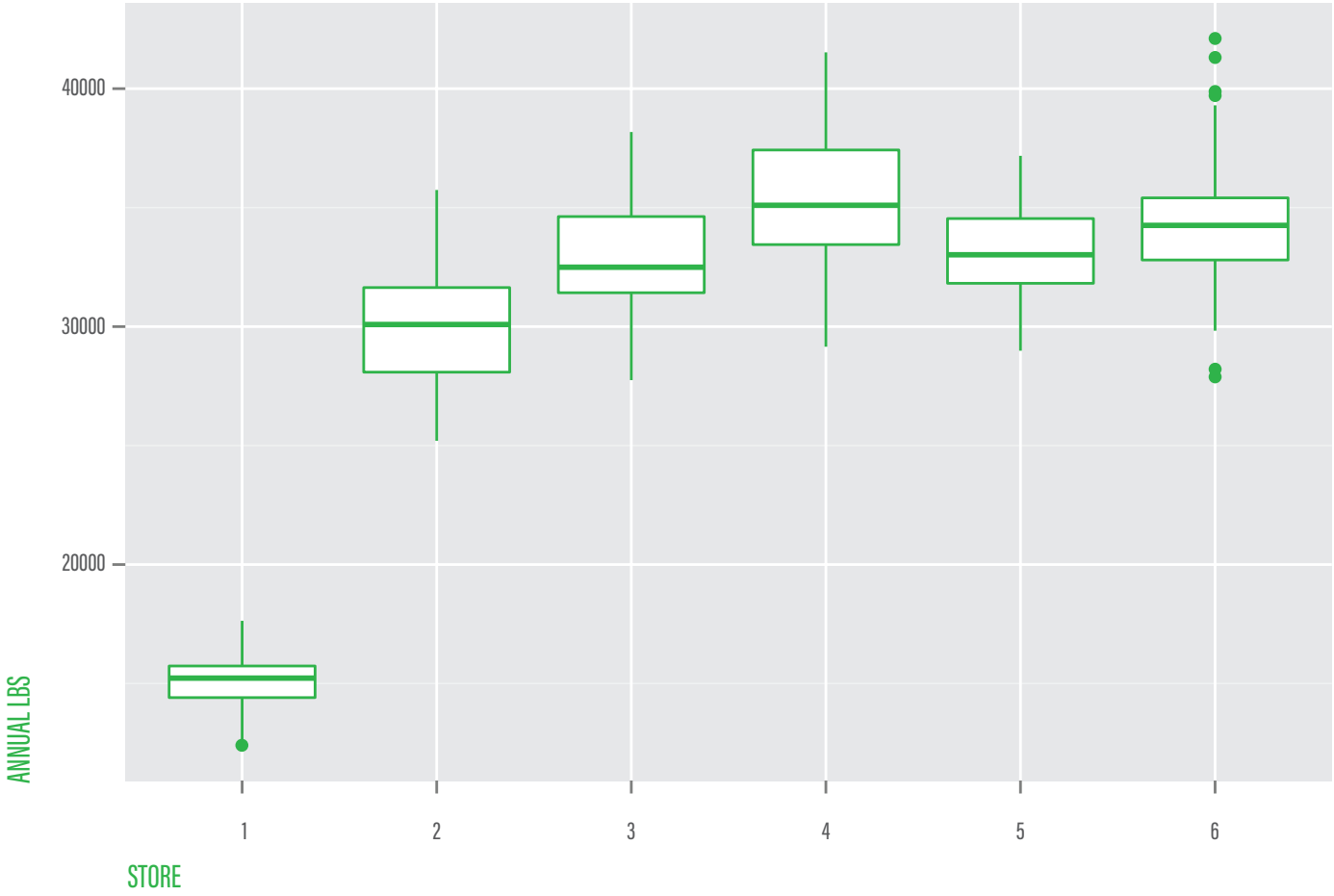


Figure 3.5: Daily and annual representative grocer and restaurant donation weight distributions in BFR data. On most days, donations from grocers and restaurants are small, but on a handful of days a year, there are spiked in donations. Grocers' predicted annual donations to BFR average 21,000 lbs, and predicted donations annually from restaurants to BFR average 4,600 lbs.

PREDICTED MISSED OPPORTUNITY AT EXAMPLE NON-PARTICIPANT STORES

Figure 3.6: Predicted losses at nonparticipating grocers in Boulder. These stores are large relative to other grocers in Boulder, and therefore, the scale of the unrecoverd food available at each store is also large relative to donations from other, smaller stores. Predicted annual donations to BFR from these larger stores average 30,000 to 40,000 pounds and could account for an additional 210,000 pounds of food available annually to those in need in Boulder.



COMMERCIAL WASTE IN BOULDER

	ANNUAL (TONNES)		**DAILY** (LBS)	
	COMPOST (N)	TRASH (N)	COMPOST	TRASH
Supermarkets	185.0 (7)	342 (2)	1013.7	1775.3
Food Processors	34.0 (3)	4.2 (1)	185.9	23.0
Business Cafeterias	31.7 (13)	26.0 (3)	173.7	142.5
Restaurants	15.9 (14)	12.8 (9)	86.9	70.0

Table 3.1: Average annual hauling weights in tonnes for organizations in Boulder using 2014 data from EcoCycle [25]. Sample size for the averages are given in parentheses.

3.3 DONATION VERSUS COMPOSTING

As a final question, we look at the interaction between donation and compost streams at locations that participate in both waste diversion programs. Figure 3.7 compares the compost pickup weight at an example grocer and restaurant before and after participation in donation. Although the plots make it difficult to see meaningful trend, a Wilcox test confirms that there is a statistically significant reduction in the amount composted for the grocer, from a median 320 pounds per day to 105 pounds per day (p-value less than 0.05). The example restaurant does not see a significant reduction in total amount composted, producing approximately 100 pounds per day of waste both before and after participating in donation. Data at this level of detail was only available for a small number of locations in our study who gave consent to share their data, and whom EcoCycle was able to provide detailed data. Hence, we cannot claim these locations are representative examples.

In this study, we advocate both donation and composting as effective means of waste diversion to complement education and training programs around source reduction. These results show that donation likely diverts a small but nontrivial amount of waste from the compost stream at locations that participate in both programs.

3.4 LIMITATIONS

Although the corpus of data is quite large (more than a year's worth of detailed data from each of the two biggest food recoverers in Boulder), we are limited in what we can describe to those organizations for which we have data and the resolution of that dataset. Boulder Food Rescue volunteers measure food rescued using simple floor scales, which are not finely calibrated, or in some cases, estimate the weight when scales are not available.

Data from CFS is from 2010. Data from BFR is from 2013/2014. Unfortunately, CFS was not willing to share detailed recovery information for recent years for this study. As BFR was not in operation in 2010, we cannot estimate a reduction in amount recovered by CFS due to overlap in the CFS and BFR models at some locations. For this study we have assumed that CFS recovery is largely focused on less perishable food (canned goods, dry goods, dairy, milk and some produce) while BFR is focused on highly perishable food (produce, bakery items, and prepared food). As such, the overlap between these rescue operations is assumed to be marginal and largely complementary.

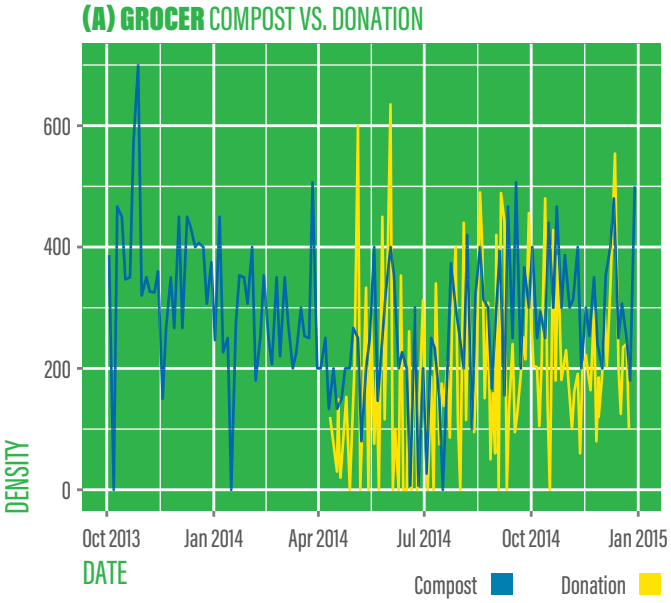
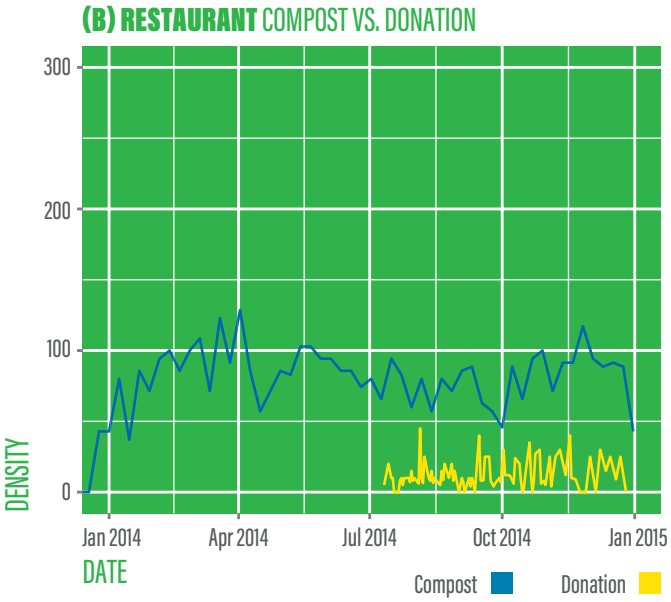


Figure 3.7: Compost weights and donation weights for a grocer and restaurant in our study before and during participation in donation programs. Data at this level of detail was only available for a small fraction of participating locations, so we cannot claim that these are representative locations.



REFERENCES

[1] Boulder food rescue. http://boulderfoodrescue.org.

[2] Cropmobster community exchange. http://sfbay.cropmobster.com/.

[3] End food waste. http://www.endfoodwaste.org/.

[4] Environmental protection agency (epa) food recovery challenge. http://www.epa.gov/foodrecoverychallenge/.

[5] factual. http://www.factual.com/.

[6] Feeding america. http://www.feedingamerica.org/.

[7] Feeding forward. http://feedingforward.com/.

[8] Food donation connection. http://www.foodtodonate.org/.

[9] Quick tap survey. http://www.quicktapsurvey.com/.

[10] United nations food and agriculture organization (un fao) save food initiative. http://www.fao.org/save.food/en/.

[11] Usda food waste challenge. http://www.usda.gov/oce/foodwaste/index.htm.

[12] Zero percent. http://zeropercent.us/.

[13] Table 217. per capita consumption of major food commodities: 1980 to 2009. Statistical abstract of the united states, US Census Bureau, 2012.

[14] Attention homes. http://www.attentionhomes.org/, March 2015.

[15] Boulder housing partners. https://www.boulderhousing.org/, March 2015.

[16] Environmental Protection Agency. Waste reduction model (warm). http://www3.epa.gov/warm/, March 2015.

[17] Sustainable America. I value food. http://ivaluefood.com, March 2015.

[18] Keith James Andrew Parry and Stephen LeRoux. Strategies to achieve economic and environmental gains by reducing food waste. Technical report, Waste & Resources Action Programme (WRAP), 2015.

[19] Jonathan Bloom. *American Wasteland: How America Throws Away Nearly Half of Its Food (and What We Can Do About It).* Da Capo Lifelong Books, 2010.

[20] The Editorial Board. Food waste grows with the middle class. *The New York Times,* February 27 2015.

[21] Jean C. Buzby, Je.rey Hyman, Hayden Stewart, and Hodan F. Wells. The value of retail-and consumer-level fruit and vegetable losses in the united states. *Journal of Consumer Affairs,* 45(3):492–515, 2011.

[22] Victoria Cavalier. Seattle imposes fine for too many food scraps in the garbage. *Reuters,* September 23 2014.

[23] West Coast Climate and Materials Management Forum. A toolkit to reduce household food waste. http://westcoastclimateforum.com/food, March 2015.

[24] Stuart Coles. *An Introduction to Statistical Modeling of Extreme Values.* Springer, 2001.

[25] Dale Ekart. Ecocycle waste hauling data. Personal Communication, March 2015.

[26] Next Generation Food. Food waste infographic. http://web.archive.org/web/20110419190046/http://www.nextgenerationfo news/infographics/100303-Food-Waste.png, March 2015. Next Generation Food was a UK-based think-tank which is no longer in operation.

REFERENCES (CONTINUED)

[27] The Center for an Agricultural Economy. Vermont food venture center. http://www.hardwickagriculture.org/for-food-businesses/vermont-food-venture-center, March 2015.

[28] Ronald Fowler and Amy Henchey. In-kind contributions. *IRS EO CPE Text -Section E,* 1994.

[29] Meg Graham. Google awards Chicago-based feeding america 1.6 million grant. *Chicago Tribune,* December 24 2014.

[30] Dana Gunders. Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. Issue Paper 12-06-B, National Resources Defense Council (NRDC), August 2012.

[31] L.L.M. Program in Agricultural and Food Law. Food recovery: A legal guide. Technical report, The University of Arkasas School of Law, 2013.

[32] Vermont State Legislature. No. 148. an act relating to establishing universal recycling of solid waste. (h.485). http://www.leg.state.vt.us/docs/2012/Acts/ACT148.pdf, 2012.

[33] Rob Martinez. Boulder County public health. Personal Communication -Database of Commercial Kitchens within the City of Boulder, February 2015.

[34] Ron Nixon. Food waste is becoming serious economic and environmental issue, report says. *The New York Times,* February 25 2015.

[35] City of Boulder. Final organic waste management feasibility evaluation report for boulder county. http://www.bouldercounty.org/doc/rc/orgwastemanfeas.pdf, October 2010.

[36] City of Boulder. 2014 county-wide diversion data. Personal communication, November 2015.

[37] University of Colorado Environmental Center. Food recovery data. Personal Communication, March 2015.

[38] Office of the Chief Economist. USDA. Usda's commitments and deliverables through 2014. http://www.usda.gov/oce/foodwaste/usda commitments.html, 2014.

[39] Philip R. O'Leary and Patrick W. Walsh. Decision makers guide to solid waste management. Technical Report EPA 530-R-95-023, Solid and Hazardous Waste Education Center. University of Wisconsin Madison., 1995. Chapter 5: Source Reduction.

[40] A. N. Oppenheim. *Questionnaire Design, Interviewing and Attitude Measurement*. Bloomsbury Academic, 2000.

[41] Caleb Phillips, Rhonda Hoenigman, Becky Higbee, and Tom Reed. Food redistribution as optimization. Technical Report CU-CS-1085-11, University of Colorado, Boulder, 2011.

[42] Caleb Phillips, Rhonda Hoenigman, Becky Higbee, and Tom Reed. Understanding the sustainability of retail food recovery. *PLoS ONE,* 8(10):e75530, 10 2013.

[43] Liz Roland. Efaa food recovery data. Personal Communication, March 2015.

[44] Internal Revenue Service. 170(e)3. 26 U.S. Code 170 -Charitable, etc., contributions and gifts, 2015.

APPENDIX A
RETAIL FOOD WASTE SURVEY

A.1 CONSENT TO PARTICIPATE

3. Do you agree to participate? (Yes or No)

A.2 YOU AND YOUR EMPLOYER

1. Company Name
2. Company Type (Grocery, Restaurant, Other)
3. Job Title
4. Phone Number
5. Email Address
6. Number of employees at your company (approximate is okay)
7. Number of employees in your department (approximate is okay)
8. Employment Status (Full Time, Part Time)
9. Length of Employment (Years and Months)
10. Briefly describe your job duties

A.3 WASTE STREAM

1. Likert (Food Waste)
   (a) My company throws away a lot of food
   (b) My company does a good job of using or quick-selling food that is close to expiry
   (c) A lot of the food we throw away is still edible
   (d) My company works to reduce the food waste we generate
   (e) My company discards a lot of food that could be donated
   (f) Employees at my company throw a lot of food in the trash that could be donated
2. Does your company compost (Yes or No (skips next question))
3. Likert (Compost)
   (a) My company has a clear protocol for composting food
   (b) Composting at my company is easy
   (c) My company doesn't compost as much as it could
   (d) Employees at my company wish there were more composting at our store
   (e) Some of the food my company composts is good enough to sell

APPENDIX A (CONTINUED)
RETAIL FOOD WASTE SURVEY

A.4 FOOD RECOVERY

1. Which organizations does your company regularly donate surplus food to (if any)?
2. How often do organizations pick up food?
3. How much time per week do you spend preparing food for donation?
4. Is your company concerned about liability from donating excess food? (Yes or No)
5. Is your company concerned about harm to its brand or image from donating food? (Yes or No)
6. Estimate the amount of otherwise edible food that is DISCARDED at your organization each day
7. Estimate the amount of otherwise edible food that is DONATED at your organization each day
8. Likert (Donation)
   (a) We donate a lot of food to recovery organizations
   (b) The employees in my company feel motivated to donate food
   (c) Every employee is trained on food disposal, composting, and donation
   (d) My company has a clear protocol for donating food
   (e) My company has infrastructure in place to support food donation
   (f) We have produce that we could donate that often gets discarded or composted

A.5 PROCESS AND PROTOCOL

1. Does your company have someone who is in charge of sustainability/green issues? (Yes or No)
2. What kind of incentives does your company have for preparing food for donation?
3. Does your company have a clear training program for di.erentiating between food that should be composted or donated?
4. How could your training be made more e.ective, if at all, for addressing situations employees encounter for composting, disposing, or donating food?
5. Does your organization repurpose excess or leftover food internally?
6. If so, in which ways (e.g., juice bar, next day's meals, deli, prepared foods, etc.)?
7. Do you o.er your customers a discount for "seconds", "day olds", or "imperfects"?
8. Do you think your company could do more to make use of excess food internally?

APPENDIX B
SURVEYOR PROTOCOL

1. Call the restaurant/grocer a day before visiting. Ask for a manager/owner. Inform them of the aims of the research and that they have been selected randomly for participation. You will be visiting the following day to survey the manager and some employees. The survey takes between 5 and 10 minutes to fill out, and is not an inspection.

2. If a manager is not present when you call, ask for the manager's name and hours for the following day. Leave a message that youll be coming in.

3. Visit storefront during pre-scheduled time prepared with the survey device and informational materials about the survey. Find your contact, or a manager, and arrange to survey at least one member of the management sta. and one regular (non-management) employee.

4. Pull up the informed consent agreement at the start of each survey, explain what it says and make sure they click "I agree" on the next question before continuing.

5. Have the manager fill it out first. Next, ask the manager to introduce you to one or more employees to take it as well. Endeavor to talk to the people in the back handling the food, at restaurants, the kitchen sta., and at grocers the receiver and the people culling food.

6. Thank everybody for their time!

APPENDIX C
SURVEY CONSENT AGREEMENT

You are being invited to participate in a research study titled City of Boulder Food Waste Audit. This study is being conducted by Boulder Food Rescue under contract from the City of Boulder. Your employer was randomly selected to participate in this study. The purpose of this research study is to understand sources of food waste and successful techniques to reduce food waste in the City of Boulder . If you agree to take part in this study, you will be asked to complete a survey/questionnaire using a tablet computer. This survey/questionnaire will ask about your experiences at your employer dealing with food in the waste stream. It will take you 5 to 10 minutes to complete. You may not directly benefit from this research however, we hope that your participation in the study may increase knowledge about causes of food waste in our city as well as inform policies and systems for recovering or preventing it. We believe there are no known risks associated with this research study however, as with any survey whose data is stored electronically the risk of a breach of confidentiality is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by (a) not collecting your name, age, or other personally identifying information and (b) anonymizing your employer's identity in published results. Your participation in this study is completely voluntary and you can withdraw at any time. You are free to skip any question that you choose. If you have questions about this project or if you have a research related problem, you may contact the research administrator(s), 720-4455-BFR, info@boulderfoodrescue.org. By signing the survey and choosing "agree" you are indicating that you are at least 18 years old, have read and understood this consent form and agree to participate in this research study.

APPENDIX D
DESIGN ACCREDATION

Layout and design of this food waste audit was provided by Rodne Design Studios. The following icons have been used from the Noun Project (thenounproject.com): Weight by José Hernandez, Global Warming by Francesca Ameglio, drop by Wayne Tyler Sall, Barrel by Evgeniy Artsebasov, Favorite Chat by icon 54, Restaurant by Federico Panzano, Tablet by Gerald Wildmoser, Conversation by Márcio Duarte, Degradation by Michael Senkow, Earth by Arthur Shlain, solar system by Sergey Demushkin, cycle by Meaghan Hendricks, Global Warming by Mark S Waterhouse, compostable by Luca Reghellin, Sheep by gira Park, Store by Claire Taylor, data map by Viktor Vorobyev, Map Marker by Rémy Médard, Location by Owen Payette McGarry, Bubble Comparision by Meaghan Hendricks, Leaf Invoice by Till Teenck, scheme by Gregor Črešnar, Line Graph by Aha-Soft, Network by Oliviu Stoian, Cognitive Modeling by Yu Luck, Coffee by Marek Polakovic, and 3-point diagram by Advan Shumiski.